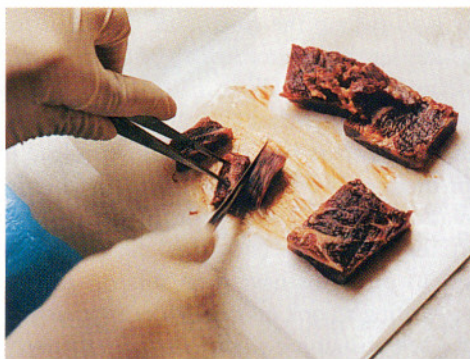


# FISHING *for* EVIDENCE

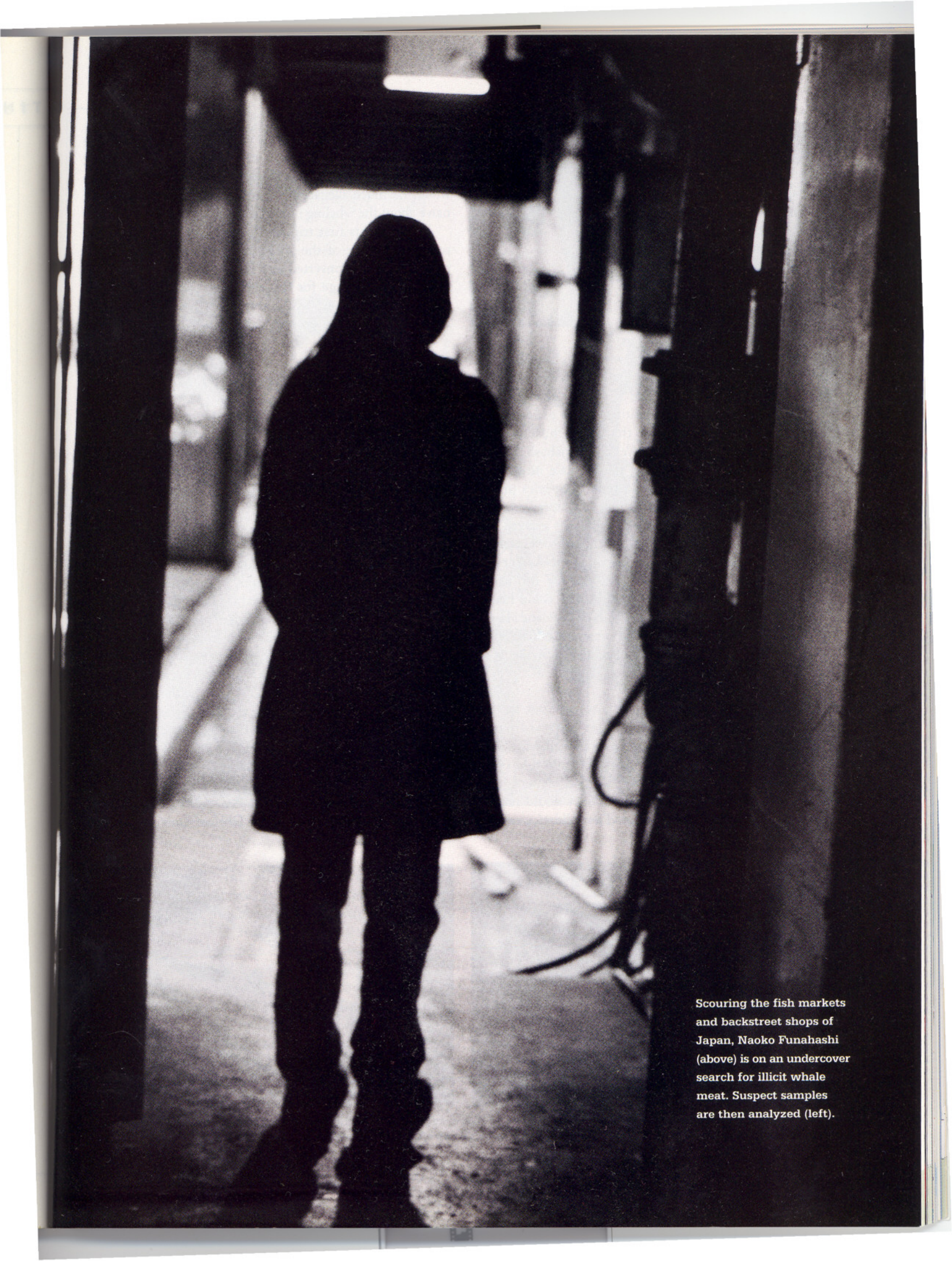
Powerful enough to track an individual animal from birth to marketplaces around the world, tiny twists of DNA could bust the illegal trade in protected species.

**A** 40-FOOT THUMB CLUTCHING A GIANT CELL PHONE LOOMS on a billboard beyond the rain-spattered window. It's seven o'clock on a Saturday night, and Scott Baker is crouched over a small bedside table on the sixth floor of a Tokyo business hotel. Dressed in a cotton sweater, black jeans, and surgical gloves, he places a mite-size shard of meat from Specimen J98D33 into a clear, thin tube—a first step in decoding the sample's DNA. ■ Purchased in a small coastal town in central Japan, J98D33 is one of 120 samples of whale meat—sashimi, marinated steak, bacon, skin, and blubber—gathered in vials on the hastily made bed. An undercover agent bought these products for as much as \$430 per pound. With the bare bones of a genetics lab brought into Japan in a black suitcase, Baker, Gina Lento, and graduate student Merel Dalebout, biologists from the University of Auckland in New Zealand, are hoping to unlock the secrets of the marketplace. ■ Baker and his colleagues have started a molecular revolution in the wildlife trade.



By **JOSEPH ROMAN** Photography by **MAX AGUILERA-HELLWEG**





Scouring the fish markets and backstreet shops of Japan, Naoko Funahashi (above) is on an undercover search for illicit whale meat. Suspect samples are then analyzed (left).



By unhitching life's essential double strand, he and other biologists have tracked illegal wildlife products across the globe. Once unidentifiable items, such as cooked meat or caviar, can now be traced to species, region of origin, and even individual animals killed half the world away.

At more than six feet, with a prominent, well-chiseled nose and dark-blond hair, Baker stands out in Japan. Had he tried to purchase whale products, he might have aroused the suspicions of retailers. So Naoko Funahashi, a slight woman in her late 30s from the outskirts of Tokyo, did the legwork, frequenting scores of restaurants and markets. A consultant for the Massachusetts-based International Fund for Animal Welfare, Funahashi traveled the length of Japan in search of illicit whale meat. After recording the location, price, and reputed species of each purchase, she photographed the sample and stored a cube of meat in ethanol for Baker and his colleagues to analyze.

Even if he didn't stand out, Baker could not leave Japan with the meat or a single strand of whale DNA, since the export of whale products, no matter how minute, is restricted by international trade laws. But he could make a replica of the DNA to bring back to New Zealand. For 10 days last spring, I joined Baker's crew, working from sunup to midnight copying DNA before Japanese officials, or the hotel maids, discovered our improvised lab.

**B**AKER STARTED HIS WORK IN 1991, WHEN HE WAS studying whale genetics as a postdoctoral researcher at the University of Hawaii with biologist Steve Palumbi. Sue and Don White of the Hawaiian nonprofit organization Earthtrust had heard about their work and asked Baker if they could identify whale species from processed meat. The Whites were con-



cerned that endangered species were being sold in Japanese markets. Though Baker thought it was possible, he didn't show much interest at first. "I was pretty skeptical that there would be much illegal meat," he tells me, "but I was very naive about the whaling industry."

He made his first trip to Japan in 1993. It wasn't easy setting up a state-of-the-art genetics lab in a hotel. Bedside tables had to be converted into lab benches, the mini fridge became cold storage for reagents, and an ultraviolet light table was set up next to the wardrobe. To make copies of DNA, Baker uses a process called the polymerase chain

**What would the hotel staff make of the surgical gloves, the fine-powdered chemicals, and the burner glowing on the bedside table?**

reaction, or PCR. In this process, DNA strands are unraveled by heating them, a region is targeted with short sequences of DNA called primers, and a bacterial enzyme constructs a replica. This procedure is repeated about 30 times, with the number of strands doubling during each cycle. A billion copies can be made from a few strands of DNA in a couple of hours. These genetic replicas can then be transported across international borders for analysis.

Though the work is technically legal, the thought of having to argue scientific nuances in a country where he doesn't speak the language keeps Baker on his toes; the door is locked at all times. What would the hotel staff make of the surgical gloves, the humming machinery, the fine-powdered chemicals, and the burner glowing on the bedside table?

After his first trip, Baker returned to Hawaii with PCR tubes tucked in his briefcase. The DNA strands copied from



The largest fish market in the world, the Tsukiji market in Tokyo, sells about 5 million pounds of seafood every day. The menu includes more than 400 different types of seafood—from dried sea-slug caviar to live eels. It also includes protected whales.







Desks become lab benches as geneticists Merel Dalebout and Scott Baker convert their hotel room into a makeshift laboratory.

the whale meat provided sufficient evidence for Baker and Palumbi to make some troubling identifications: They found red meat, bacon, and blubber from endangered fin whales as well as marinated steak from a humpback whale, a species that has been protected from hunting since 1966. Although the International Whaling Commission (IWC) set a moratorium in 1986 on commercial whaling, the taking of whales for scientific research is still permitted; Japan's legal harvest was restricted to an annual quota of a few hundred minke whales. No other whales should appear on the market.

In 1994 Baker and Palumbi, now at Harvard University, presented their findings to the IWC, which passed a resolution to begin monitoring the international trade in whales. The species inventory that Baker and his colleagues have compiled since his first trip in 1993 would dwarf the life

lists of most whale watchers: 19 fin whales, 4 Bryde's whales, 2 humpback whales, a sei whale, a blue whale, a blue-fin whale hybrid, minke whales, three species of beaked whales, a pygmy sperm whale, at least six species of dolphins, and a killer whale.

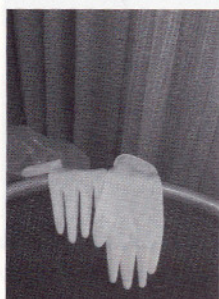
At first the Japanese Fisheries Agency questioned Baker's methods, claiming that work done in a hotel room could hardly be called science. When its challenge proved ineffective, the agency changed tactics. "I do not think there are illegal whales being sold in Japan," Shuji Ishida, councillor for the agency, told me. "We have no records of fin whales caught by Japanese fishermen. These other species are from whales that were killed and frozen before the moratorium on whaling."

Since the 1986 suspension of commercial whaling,





From bacon to blubber, from sashimi to steak, hundreds of vials of whale-meat samples are collected by Baker and his colleagues.



Japanese wholesalers have maintained a stockpile of meat from previous hunts. Although the IWC has requested an inventory of these stockpiles, no records have been released. Baker wonders if it's a cover, perhaps unintentional, for the marketing of illegally caught whales. Baker can determine if meat samples are from the same individual. During each yearly survey, he has found meat from different fin whales, even though that species hasn't been legally hunted since the moratorium. The frozen stockpile, he says, "does not explain why we're finding new fin whales on the markets in Japan. So far we've found meat from 19 individuals. If it's all from the freezer, why are new whales still showing up?"

**B**AKER AND I GO TO THE TSUKIJI FISH MARKET early one Sunday morning. Six days a week, starting before 5:00 A.M., this 56-acre market brims with marine life en route to restaurants and sushi bars. On Sunday, however, the market is closed. We have come for the Tsukiji Whale Festival.

Although whale has been consumed along the Japanese coast for centuries, the widespread distribution of *kujira*, or whale meat, dates back only a few decades. The Japan-

ese government supports the industry by holding festivals, subsidizing whaling, and serving *kujira* at school lunches. After years of fighting to continue whaling in international waters, Japanese whalers now face a need to promote domestic consumption, in an attempt to reverse a declining demand for their products. At the Tsukiji festival, smiling blue-robed attendants hand out pencil erasers shaped like bowheads and humpbacks. Posters supporting the scientific hunt, blocks of Antarctic ice, and frozen *kujira* are on display. Baker pauses over a slab as big as a doormat. "It looks like a minke," he says, running his finger over one of the folds that allow baleen whales to expand their mouths when swallowing. An elementary deduction for a cetacean biologist. But the vacuum-sealed pink-and-white meat on sale isn't so obvious.

After the festival, Baker and I walk through the stalls around the market. We come upon a shop packed as tight as an ark, with scores of endangered animals mounted in life-like poses: hawksbill sea turtles as big as manhole covers, a 10-foot crocodile, a lynx, a white wolf, and a snarling polar bear wrapped in plastic and available for 1.65 million yen, or about \$14,000. The hunger for wildlife products is not limited to food: In Japan, one out of every five people has purchased medicines made from endangered species, though most were bought as souvenirs, not for their medicinal value. Traditional products, such as tiger bone and rhinoceros





Whale fetuses on display at "Whaleland," in the coastal village of Ayukawa, where whaling and whale products are heavily promoted.

**"I was skeptical that there would be much illegal meat, but I was very naive about the industry."**

horn, are now prized mostly for their novelty. Baker looks at the dead displays: "Just think of all the projects you could start here."

Other geneticists have already begun scrutinizing wildlife products around the world. Bear gallbladders, crocodile skins, seal penises, Amazon parrots, black caviar, and turtle meat are just a few of the products that are monitored. Using DNA fragments and an expanding database of genetic markers, molecular detectives have uncovered disturbing patterns of trafficking in protected species.

Currently, one of the largest legal kills of wild animals in the world is the annual harvest of 300,000 harp and hooded seals along Canada's east coast. Brad White, director of the Natural Resources DNA Profiling and Forensic Centre in Ontario, Canada, is investigating this seal trade. I ask him what the motivation could be for

such a large kill. "The meat is not easily palatable," he says, "and fur prices are low. Basically, the killing is for penises."

A much-sought-after aphrodisiac in Asian markets, a seal penis can sell for as much as \$600, which often leads to fraud. Working with White, Asian agents bought products labeled as seal penises from Chinese medicine shops in cities from Shanghai to Toronto. Most were from harp seals, but about 25 percent of the purchases were not from seals at all. Since White couldn't sample the DNA of every species with a penis to find out what animal the appendage had belonged to, he used the Internet. GenBank is a rapidly growing database on the Web. After pasting in an unidentified DNA fragment, White can compare it with millions of DNA sequences in just a few seconds. He found penises from African wild dogs and from endangered Australian fur seals. High prices were driving retailers to trade in protected species.

White's research isn't just on lucrative, exotic products, however. Recently, Canadian wildlife officers asked his lab to analyze meat from confiscated super-market sausages. By Canadian law, wild game cannot be marketed. Yet White and his colleagues found moose and white-tailed deer meat in the sausages they tested. A butcher in Manitoba was fined \$3,000 for selling game meat. More cases are pending.







The sophisticated machinery required for this hotel room turned genetics lab can be packed up into a single, discreet suitcase.

**W**ITH THE LEVIATHAN APPETITE OF THE marketplace, no animal is safe—especially if it has a valuable hide, a prized cut of meat, or a reputation for Viagra-like properties. “If we do it right,” says geneticist Rob DeSalle, “I think molecular identification is going to have a huge impact on the trade in endangered species.”

In his lab at the American Museum of Natural History in New York City, DeSalle helped spark this revolution. More than 80 tons of sturgeon roe enter the United States each year, making this country the world’s leading importer of caviar. In 1996 DeSalle and his colleagues tested almost 100 lots of black caviar purchased in New York City; they found that almost 25 percent of the tins were falsely labeled. Eggs said to be from commercial species were actually from protected species, violating the Convention on International Trade in Endangered Species (CITES) and posing a threat to sturgeon populations worldwide. “If we don’t attempt to properly regulate the market,” he says, “all 25 species of sturgeon could be wiped out.”

In December 1998 U.S. Fish and Wildlife Service agents responded to this

threat; they uncovered a million-dollar smuggling operation. Using DNA markers, they found eggs from endangered sturgeon labeled as caviar from more abundant populations. More than 2,000 pounds of caviar were confiscated and destroyed. The suspects have been indicted and face penalties of \$250,000 and five years in prison.

By developing a genetic atlas linking genes to geography, researchers can look beyond the species level to find the region of origin for wildlife products. And their work may soon put some captive animals back in the wild. Hundreds of Galápagos giant tortoises are currently being held at the Charles Darwin Research Station in the Galápagos. Some of them were confiscated from tourists trying to leave the islands with souvenir hatchlings in their luggage. Geneticist Jeffrey Powell and his colleagues at Yale University are looking at the DNA of these tortoises. If they can find DNA markers specific to each population, they may soon be able to return the confiscated turtles to their native islands.

But why stop at the population level? Palumbi and fellow Harvard biologist Frank Cipriano have tracked the identity of a strip of whale bacon sold in a





department store in Osaka in 1993. Using mitochondrial DNA, which is DNA inherited exclusively from the mother, they identified the sample as a blue whale. Noticing that this sample was identical to a published sequence, the biologists decided to test a different region of the whale's DNA—and got another exact match. They soon realized it was the same whale. The meat was from a whale that years earlier had been identified and given the number 26 by Icelandic researchers. The whale, a 65-foot male, was born in 1965 and killed during a scientific Icelandic whaling expedition on June 29, 1989. Once rendered and stored in deep freeze, this whale found its way to the Japanese market. Looking at single whales, says Palumbi, “takes the conservation effort all the way from the species level, where it generally is, right down to the individual level. It means that we can more effectively identify whales that are illegally killed.” If a genetic ID tag is established for each harvested whale, any illegitimate product that enters the market can be identified and tracked by authorities.

Protected whale species are still getting into the markets. I spoke to Baker after he returned from an International Whaling Commission meeting in Grenada last May. Of the 120 Japanese samples Baker and Dalebout analyzed in 1999, they found a fin whale, a sperm whale for the first time, 4 sei whales, and 17 dolphins and porpoises.

Faced with such results, the Japanese and Norwegian governments have agreed to take genetic profiles of each animal harvested by their whalers. Japanese officials have already begun surveying the whale market themselves.

**O**N MY LAST DAY IN TOKYO, I RETURN TO THE Tsukiji Fish Market. With thousands of rubber boots skating over slick cobblestones, the bright flash of four-foot tuna knives, and the squeal of Styrofoam boxes stuffed with abalone, mackerel, shrimp, octopus splayed like tropical orchids, and pricey wedges of bluefin tuna, it's a gourmand's heaven and a fish's hell. In just a few hours, I watch hundreds of tons of seafood from all the oceans of the world pass under Tsukiji's gaping roof.

I thought of something George Amato, director of conservation genetics at the Wildlife Conservation Society, had told me. Amato has worked on the prosecution of cases involving crocodile skins, alligator meat, and bear gallbladders. “Globalization of trade has a tremendous impact on wildlife populations,” he said. “Everything is easy now. You can go on the Internet and find someone who is selling a Galápagos tortoise. It takes just 24 hours to move stuff from anywhere in the world to a major market.” The “stuff” that had been alive and wild just days before was now packaged for sale. And what clues remain? A few twists of DNA. ■

*Joseph Roman is a writer and conservation biologist living in Massachusetts. He has studied North Atlantic right whales and the turtle-meat trade using molecular markers.*

## CHASING *the* WHALE



The ocean reddens after a 1968 whale hunt off the Faeroe Islands.

*Kujira, hvalkjott, muktuk, gorae.* By any name, whale meat has provided coastal communities with essential protein and fats for centuries. In the 20th century, however, as many species began to disappear, the International Whaling Commission (IWC) was formed to conserve whale populations and oversee the whaling industry. Many of the great whales—right whales, gray whales, humpback whales, blue whales, and sperm whales—have been protected for decades.

In 1986 the IWC established a moratorium on the commercial hunting of all whale species. Although most nations agreed to these guidelines, Japan objected to the classification of sperm whales as protected stock. As a result, they can still appear on Japanese markets.

Japan also legally kills approximately 440 minke whales from the Antarctic and 100 from the North Pacific annually under self-issued research permits. The necessity of this lethal research has met with international skepticism. The by-products of the hunt are sold to domestic wholesalers, and Japan

makes the final decision as to where research ends and commercial whaling begins.

Small cetaceans, including dolphins and porpoises, are not regulated by the IWC. Since the ban on great whales was initiated, Japanese whalers have increased their hunt of small cetaceans, most notably the Dall porpoise. In 1996 Japan reported an annual catch of 16,000 of these coastal dolphins, the largest hunt of cetaceans in the world.

Japan isn't the only nation to continue whaling. In the 1990s a rift formed between IWC member states that support whaling and those, such as Australia, New Zealand, Great Britain, Italy, and the United States, that defend the commercial ban. Norway lodged an objection against the moratorium in 1992 and resumed commercial hunting of minke whales in the Norwegian Sea. The Inuit of Greenland and North America continue traditional hunts of bowheads and other whales. And recently, in the United States, Makah whalers had their first gray whale hunt in more than 60 years.

—J. R.